CLAIMS

WE CLAIM:

1. A material system investigating system comprising a source of electromagnetic radiation, a means for supporting a sample system, and a detector, such that in use a beam of electromagnetic radiation is provided by said source of electromagnetic radiation and is caused to reflect from a sample system placed on said means for supporting a sample system and enter said detector, said material system investigating system further comprising at least one electromagnetic beam intercepting angle-of-incidence changing system comprising elements which are easily functionally entered into the locus of the electromagnetic beam on both sides of said sample system, which at least one electromagnetic beam intercepting angle-of-incidence changing system serves to direct said electromagnetic beam onto substantially the same spot on the sample system as is the case where the said at least one electromagnetic beam intercepting angle-of-incidence changing system is not functionally present, but at an angle-of-incidence which is different than that when said at least one electromagnetic beam intercepting angle-of-incidence changing system is not functionally present, said at least one electromagnetic beam intercepting angle-of-incidence changing system not effecting, or requiring change of, the locus of the electromagnetic beams outside said at least one electromagnetic beam intercepting angle-of-incidence changing system, on either side of said means for supporting a sample system, hence does not require said material system investigating system to comprise multiple sources and/or detectors or the change of position of the source of electromagnetic radiation and/or detector to effect change said

angle-of-incidence.

2. A material system investigating system as in Claim 1, in which said at least one electromagnetic beam intercepting angle-of-incidence changing system comprises, on each side of said means for supporting a sample system, at least one selection from the groups consisting of:

multiple angle prism(s); and
a system of mirrors;

said at least one electromagnetic beam intercepting angle-of-incidence changing system being slidably mounted to a guide element such that the functional presence thereof in the pathway of the locus of the electromagnetic beams on both sides of said means for supporting a sample system is effected by physical sliding motion of said at least one electromagnetic beam intercepting angle-of-incidence changing system along said guide element.

3. A material system investigating system as in Claim 1, in which said at least one electromagnetic beam intercepting angle-of-incidence changing system comprises a first multiangle prism on the incident side of said means for supporting a sample system and a second multiangle prism thereafter, said first and second multiangle prisms each having a first and a second side, each said multiangle prism presenting with first and second inner surfaces associated with said first and second sides, respectively, the first and second side of each multiangle prism having means for changing the properties of inner surface thereof from essentially transmissive to essentially reflective, each said multiangle prism being oriented such that an electromagnetic beam entering thereinto encounters the first or second inner surface thereof and either passes therethrough and progresses on

to contact a sample system placed on said means for supporting a sample system, or reflects from said first or second inner surface thereof and then from said second or first inner surface thereof, respectively, and then progresses on to contact a sample system placed on said means for supporting a sample system.

4. A material system investigating system as in Claim 3, which further comprises at least one shutter door which can be opened to let the electromagnetic beam pass, or closed to block its passage, said at least one shutter door being positioned in the electromagnetic beam locus selected from the group consisting of:

defined by passage through said first or second side of said first multiangle prism; and

defined by reflection from said first or second side of said first multiangle prism;

said at least one shutter door being positioned between the first multiangle prism and the means for supporting a sample system and/or between said means for supporting a sample system and said second multiangle prism.

5. A material system investigating system as in Claim 1, in which said at least one electromagnetic beam intercepting angle-of-incidence changing system comprises, on first and second sides of said means for supporting a sample system, first and second beam splitters, respectively, which first and second beam splitters each pass approximately half, and reflect approximately half of a beam of electromagnetic radiation caused to be incident thereupon at an oblique angle to a surface thereof; said at least one electromagnetic beam intercepting angle-of-incidence changing system further comprising a first reflective means positioned to

intercept the approximately half of the electromagnetic beam which reflects from said first beam splitter on the incident side of said means for supporting a sample system and direct it toward said means for supporting a sample system; and also further comprising a second reflective means positioned after said means for supporting a sample system to intercept an electromagnetic beam which reflects from a sample system placed on said means for supporting a sample system and direct it toward the second beam splitter;

said material system investigating system further comprising at least one shutter door which can be opened to let the electromagnetic beam pass, or closed to block its passage, said at least one shutter door being positioned in the pathway of the electromagnetic beam between which progresses along a locus selected from the group consisting of:

> defined by passage through said first beam splitter; and
> defined by reflection from said first beam splitter;

on either side of said means for supporting a sample system.

6. A material system investigating system as in Claim 1 or 2 or 3 or 4 or 5 which is a system selected from the group consisting of:

> ellipsometer;
> polarimeter;
> reflectometer; and
> spectrophotometer;

operating in at least one wavelength range selected from the group consisting of:

VUV;
UV;
Visible;
Infrared;
Far Infrared;
Radio Wave;

and is applied in a setting selected from the group consisting of:

in-situ; and
ex-situ.

7. A material system investigating system as in Claim 1 or 2 or 3 or 4 or 5 in which said material system investigating system is mounted to an X-Y-Z position control system, and which is oriented to investigate a surface of a sample system oriented in a horizontal or vertical or a plane thereinbetween.

8. A material system investigating system as in Claim 1, which includes at least two multiple angle prisms, one being present on one side of said sample system, and the other thereof being present on the other side of said sample system.

9. A material system investigating system as in Claim 1, which includes lenses positioned to focus a beam of electromagnetic radiation onto a sample system.

10. A material system investigating system as in Claim 1, which includes means for adjusting the orientation of at least one electromagnetic beam intercepting angle-of-incidence changing system, optionally in simultaneous combination which includes lenses positioned to focus a beam of electromagnetic radiation onto a sample system and recollimate the beam of electromagnetic

radiation which reflects from said sample system.

11. A material system investigating system as in Claim 1, in which the at least one electromagnetic beam intercepting angle-of-incidence changing system comprises, on first and/or second sides of said means for supporting a sample system, at least one system of mirrors, said at least one system of mirrors being comprised of:

a means for changing the propagation direction of an initial beam of electromagnetic radiation without significantly changing the phase angle between orthogonal components thereof, said means comprising two pairs of reflecting mirrors oriented so that said initial beam of electromagnetic radiation reflects from a first reflecting means in the first pair of reflecting means to a second reflecting means in said first pair of reflecting means, in a first plane; and such that the beam of electromagnetic radiation which reflects from the second reflecting means in said first pair of reflecting means reflects from the first reflecting means in said second pair of reflecting means to said second reflecting means in said second pair of reflecting means, in a second plane which is essentially orthogonal to said first plane; such that the direction of propagation of the beam of electromagnetic radiation reflected from the second reflecting means in said second pair of reflecting means is different from the propagation direction of the initial beam of electromagnetic radiation; the basis of operation being that changes entered between the orthogonal components by the first pair of reflective means is canceled by that entered by the second pair of reflective means.

12. A method of calibrating a material system investigation system comprising the steps of:

a. providing a material system investigation system comprising a source of a polychromatic beam of electromagnetic radiation, a polarizer, a stage for supporting a sample system, an analyzer, a dispersive optics and at least one detector system which contains a multiplicity of detector elements, said material system investigation system optionally comprising at least one compensator(s) positioned at a location selected from the group consisting of:

before said stage for supporting a sample system, and
after said stage for supporting a sample system, and
both before and after said stage for supporting a sample system;

such that when said material system investigation system is used to investigate a sample system present on said stage for supporting a sample system, at least one selection from the group consisting of:

said analyzer;
said polarizer; and
at least one of said at least one compensator(s);

is/are caused to continuously rotate while a polychromatic beam of electromagnetic radiation produced by said source of a polychromatic beam of electromagnetic radiation is caused to pass through said polarizer and said compensator(s), said polychromatic beam of electromagnetic radiation being also caused to interact with said sample system, pass through said analyzer and interact with said dispersive optics such that a multiplicity of essentially single wavelengths are caused to simultaneously enter a corresponding multiplicity of detector elements in said at least one detector system;

said material system investigating system further comprising at least one angle-of-incidence changing system which is easily functionally entered into the locus of the electromagnetic beam on both sides of said means for supporting a sample system, which at least one angle-of-incidence changing system serves to direct said electromagnetic beam onto substantially the same spot on the sample system as is the case where the said at least one angle-of-incidence changing system is not present, but at an angle-of-incidence which is different when said at least one angle-of-incidence changing system is and is not functionally present, said at least one angle-of-incidence changing system not effecting, or requiring change of, the locus of the electromagnetic beams outside said at least one angle-of-incidence changing system, on either side of said means for supporting a sample system, hence does not require multiple sources and/or detectors or change of position of the source of electromagnetic radiation and/or detector to effect change said angle-of-incidence;

b. along with step a., developing a mathematical model of said material system investigation system which comprises as calibration parameter variables selections from the group consisting of:

polarizer azimuthal angle orientation;
present sample system PSI;
present sample system DELTA;
compensator azimuthal angle orientation(s);
matrix components of said compensator(s); and
analyzer azimuthal angle orientation;
angle-of-incidence changing system representation;

which mathematical model is effectively a transfer function which enables calculation of electromagnetic beam intensity as a function of wavelength detected by a detector element, given intensity as a function of wavelength provided by said source of a polychromatic beam of electromagnetic radiation;

c. causing a polychromatic beam of electromagnetic radiation produced by said source of a polychromatic beam of electromagnetic radiation, to pass through said polarizer, interact with a sample system caused to be in the path thereof, pass through said analyzer, and interact with said dispersive optics such that a multiplicity of essentially single wavelengths are caused to simultaneously enter a corresponding multiplicity of detector elements in said at least one detector system, with said polychromatic beam of electromagnetic radiation also being caused to pass through present compensator(s);

d. obtaining an at least two dimensional data set of intensity values vs. wavelength and a parameter selected from the group consisting of:

angle-of-incidence of said polychromatic beam of electromagnetic radiation with respect to a present sample system, and

azimuthal angle rotation of at least one element selected from the group consisting of:

said polarizer; and
said analyzer;
at least one of said at least one compensator(s);

while at least one selection from the group consisting of

said polarizer; and
said analyzer;
at least one of said at least one compensator(s);

is caused to continuously rotate;

e. performing a mathematical regression of said mathematical model onto said at least two dimensional data set, thereby evaluating calibration parameters in said mathematical model;

said regression based calibration procedure evaluated calibration parameters serving to compensate said mathematical model for non-achromatic characteristics and non-idealities of said compensator(s), and for azimuthal angles of said polarizer, analyzer and compensator(s) and for said angle-of-incidence changing system.

13. A method of calibrating a material system investigation system investigation system as in Claim 12 which further comprises including at least one selection from the group consisting of:

calibration parameters for detector element image persistence; and
read-out nonidealities in the mathematical model;

and further evaluating said calibration parameters for detector element image persistence and read-out nonidealities in said regression procedure.

14. A method of calibrating a material system investigation system as in Claim 12 in which the step of developing a calibration parameter containing mathematical model thereof includes the steps of providing a matrix representation of each

of said polarizer, present sample system, said compensator(s), and said analyzer, and determining a mathematical transfer function relating electromagnetic beam intensity out to intensity in, as a function of wavelength, by multiplication of said matrices in a spectroscopic rotating element material system investigation system element presence representing order.

15. A method of calibrating a material system investigation system as in Claim 12, which further comprises the step of parameterizing calibration parameters by representing variation as a function of at least one member of the group consisting of:

wavelength;
angle-of-incidence of said polychromatic beam of electromagnetic radiation with respect to a present sample system,
sample system characterizing parameters; and

azimuthal angle orientation of one element selected from the group consisting of:

said polarizer; and
said analyzer;

by a parameter containing mathematical equation, said parameters being evaluated during said mathematical regression.

16. A method of calibrating a material system investigation system as in Claim 15, in which calibration parameters which are parameterized are selected from the group consisting of:

polarizer azimuthal angle orientation;
compensator azimuthal angle orientation(s);
matrix components of said compensator(s), and

analyzer azimuthal angle orientation;

each as a function of wavelength.

17. A method of calibrating a material system investigation system as in Claim 12 in which the sample system is selected from the group consisting of:

open atmosphere with the spectroscopic rotating compensator material system investigation system being oriented in a "straight-through" configuration; and

other than open atmosphere with the spectroscopic rotating compensator material system investigation system being oriented in a "sample-present" configuration.

18. An sample system investigation system for application in investigating a sample system with electromagnetic radiation, sequentially comprising:

a. a source of a beam electromagnetic radiation;

b. a polarizer element;

c. optionally a compensator element;

d. additional element(s);

e. a sample system;

f. additional element(s);

g. optionally a compensator element;

h. an Analyzer element; and

i. a Detector System;

wherein said additional component(s) in d. and f. each comprise at least one electromagnetic beam intercepting angle-of-incidence changing system element which can be easily entered into the locus of the electromagnetic beam on both sides of said sample system, which at least one electromagnetic beam intercepting angle-of-incidence changing system elements serves to direct said electromagnetic beam onto substantially the same spot on the sample system as is the case where the said at least one electromagnetic beam intercepting angle-of-incidence changing system elements are not present, but at an angle-of-incidence which is different than that when said at least one electromagnetic beam intercepting angle-of-incidence changing system is not present, said at least one electromagnetic beam intercepting angle-of-incidence changing system elements not effecting, or requiring change of, the locus of the electromagnetic beams outside said at least one electromagnetic beam intercepting angle-of-incidence changing system elements, on either side thereof, hence does not require multiple sources and/or detectors or change of position of the source of electromagnetic radiation and/or detector to effect change said angle-of-incidence.

19. An sample system investigation system for application in investigating a sample system with electromagnetic radiation as in Claim 18, in which each electromagnetic beam intercepting angle-of-incidence changing system is a selection from the group consisting of:

multiangle prisms; and
a plurality of mirrors.

20. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements, said parameterized equations enabling, when parameters therein are properly evaluated, independent calculation of retardation entered by each of said input output electromagnetic beam intercepting angle-of-incidence changing system elements between orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, at least one of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements being birefringent, said method comprising, in a functional order, the steps of:

a. providing spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements, at least one of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements demonstrating birefringence when a beam of electromagnetic radiation is caused to pass therethrough, there being a means for supporting a sample system positioned between said input and output electromagnetic beam intercepting angle-of-incidence changing system elements;

b. positioning an ellipsometer system source of electromagnetic radiation and an ellipsometer system detector system such that in use a beam of electromagnetic radiation provided by said source of electromagnetic radiation is caused to

pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, interact with a sample system, in a plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system element and enter said detector system;

c. providing a sample system to said means for supporting a sample system, the composition of said sample system being sufficiently well known so that retardance entered thereby to a polarized beam of electromagnetic radiation of a given wavelength, which is caused to interact with said sample system in a plane of incidence thereto, can be accurately modeled mathematically by a parameterized equation which, when parameters therein are properly evaluated, allows calculation of retardance entered thereby between orthogonal components of a beam of electromagnetic radiation caused to interact therewith in a plane of incidence thereto;

d. in combination with the other steps, providing a mathematical model for said ellipsometer system and said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, in which electromagnetic radiation is caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, and said sample system, comprising separate parameterized equations for independently calculating retardance entered between orthogonal components of a beam of electromagnetic radiation caused to pass through each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, and interact with said sample system in a plane of incidence thereto; such that where parameters in said mathematical model are properly evaluated, retardance entered between orthogonal components of a beam of electromagnetic which passes through each of said input and output electromagnetic beam

intercepting angle-of-incidence changing system elements, and interacts with said sample system in a plane of incidence thereto can be independently calculated from said parameterized equations;

e. obtaining a spectroscopic set of ellipsometric data with said parameterizable sample system present on the means for supporting a sample system, utilizing a beam of electromagnetic radiation provided by said source of electromagnetic radiation, said beam of electromagnetic radiation being caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, interact with said parameterizable sample system in a plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system element and enter said detector system;

f. by utilizing said mathematical model provided in step d. and said spectroscopic set of ellipsometric data obtained in step e., simultaneously evaluating parameters in said mathematical model parameterized equations for independently calculating retardance entered between orthogonal components in a beam of electromagnetic radiation caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, interact with said sample system in a plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system element;

to the end that application of said parameterized equations for each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements and sample system for which values of parameters therein have been determined in step f., enables independent calculation of retardance entered between orthogonal components of a beam of electromagnetic radiation by

each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, and said sample system, at given wavelengths in said spectroscopic set of ellipsometric data, said calculated retardance values for each of said input electromagnetic beam intercepting angle-of-incidence changing system element, output electromagnetic beam intercepting angle-of-incidence changing system element and sample system being essentially uncorrelated.

21. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 20, in which the step f. simultaneous evaluation of parameters in said mathematical model parameterized equations for said parameterizable sample system, and for said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, is achieved by a square error reducing mathematical curve fitting procedure.

22. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 20, in which the step d. provision of a mathematical model for said ellipsometer system and said input and output electromagnetic beam intercepting angle-of-incidence changing systems and said parameterizable sample system, involves, for each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, providing separate parameterized mathematical model parameterized equations for retardance entered to each of said two orthogonal components of a beam of electromagnetic radiation caused to pass through said

input and output electromagnetic beam intercepting angle-of-incidence changing system elements; at least one of said orthogonal components for each of said input and output electromagnetic beam intercepting angle-of-incidence changing systems being directed out of the plane of incidence of said electromagnetic beam onto said parameterizable sample system; such that calculation of retardation entered between orthogonal components of said beam of electromagnetic radiation, by said input electromagnetic beam intercepting angle-of-incidence changing system element is provided by comparison of retardance entered to each of said orthogonal components for said input electromagnetic beam intercepting angle-of-incidence changing system, and such that calculation of retardation entered between orthogonal components of said beam of electromagnetic radiation, by said output electromagnetic beam intercepting angle-of-incidence changing system element is provided by comparison of retardance entered to each of said orthogonal components for said output electromagnetic beam intercepting angle-of-incidence changing system element.

23. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 22, in which the step f. simultaneous evaluation of parameters in said mathematical model parameterized equations for said parameterizable sample system, and for said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, is achieved by a square error reducing mathematical curve fitting procedure.

24. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam

intercepting angle-of-incidence changing system elements as in Claim 20, in which the step b. positioning of an ellipsometer system source of electromagnetic radiation and an ellipsometer system detector system includes positioning a polarizer between said source of electromagnetic radiation and said input electromagnetic beam intercepting angle-of-incidence changing system, and the positioning of an analyzer between said output electromagnetic beam intercepting angle-of-incidence changing systems and said detector system, and in which the step e. obtaining of a spectroscopic set of ellipsometric data involves obtaining data at a plurality of settings of at least one component selected from the group consisting of:

said analyzer;and
said polarizer.

25. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 22, in which the step b. positioning of an ellipsometer system source of electromagnetic radiation and an ellipsometer system detector system includes positioning a polarizer between said source of electromagnetic radiation and said input electromagnetic beam intercepting angle-of-incidence changing system, and the positioning of an analyzer between said output electromagnetic beam intercepting angle-of-incidence changing system, and said detector system, and in which the step e. obtaining of a spectroscopic set of ellipsometric data involves obtaining data at a plurality of settings of at least one component selected from the group consisting of:

said analyzer; and
said polarizer.

26. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 20, in which the step of providing separate parameterized mathematical model parameterized equations for enabling independent calculation of retardance entered by said input and said output electromagnetic beam intercepting angle-of-incidence changing system elements between orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, and by said sample system, involve parameterized equations having a form selected from the group consisting of:

$$ret(\lambda) = K1 + (K2/\lambda^{z}) + (K3/\lambda^{y})$$
$$ret(\lambda) = (K1/\lambda)$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^{z}))$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^{z}) + (K3/\lambda^{y})).$$

27. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 22, in which the step of providing separate parameterized mathematical model parameterized equations for retardance entered to each of said two orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, for each of said input and output electromagnetic beam intercepting angle-of-incidence changing systems, thereby enabling independent calculation of retardance entered by said input and entered by said output electromagnetic

beam intercepting angle-of-incidence changing systems, between orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, involves, for each input and output electromagnetic beam intercepting angle-of-incidence changing systems orthogonal retardation component and for said sample system retardation, parameterized equations having a form selected from the group consisting of:

$$ret(\lambda) = K1 + (K2/\lambda^2) + (K3/\lambda^4)$$
$$ret(\lambda) = (K1/\lambda)$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2))$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2) + (K3/\lambda^4)).$$

28. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 20, in which the step a. providing of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements involves providing input and output electromagnetic beam intercepting angle-of-incidence changing system elements which are mounted on an X, Y, Z orientation control system.

29. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 22, in which the step a. providing of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements involves providing input and output electromagnetic beam intercepting

angle-of-incidence changing system elements which are mounted on an X, Y, Z orientation control system.

30. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements, said parameterized equations enabling, when parameters therein are properly evaluated, independent calculation of retardation entered by each of said input electromagnetic beam intercepting angle-of-incidence changing system element and said output electromagnetic beam intercepting angle-of-incidence changing system to at least one orthogonal component(s) of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, at least one of said input and output electromagnetic beam intercepting angle-of-incidence changing systems being birefringent, said method comprising, in a functional order, the steps of:

a. providing spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing systems, at least one of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements demonstrating birefringence when a beam of electromagnetic radiation is caused to pass therethrough, there being a means for supporting a sample system positioned between said input and output electromagnetic beam intercepting angle-of-incidence changing system elements;

b. positioning an ellipsometer system source of electromagnetic radiation and an ellipsometer system detector system such that in use a beam of electromagnetic radiation provided by said source of electromagnetic radiation is caused to

pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, interact with a sample system, in a plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system element and enter said detector system;

c. providing a sample system to said means for supporting a sample system;

d. in conjunction with other steps, providing a mathematical model for said ellipsometer system and said input and output electromagnetic beam intercepting angle-of-incidence changing system elements and said sample system, comprising, for each of said input electromagnetic beam intercepting angle-of-incidence changing system and said output electromagnetic beam intercepting angle-of-incidence changing system element, separate parameterized equations for retardance for at least one orthogonal component in a beam of electromagnetic radiation provided by said source of electromagnetic radiation, which orthogonal component is directed out-of-a-plane of incidence which said electromagnetic beam makes with said sample system in use, such that retardation entered to said out-of-plane orthogonal component can, for each of said input and output electromagnetic beam intercepting angle-of-incidence changing system, be separately calculated by said parameterized equations, where parameters in said parameterized equations are properly evaluated;

e. obtaining a spectroscopic set of ellipsometric data with said sample system present on the means for supporting a sample system, utilizing a beam of electromagnetic radiation provided by said source of electromagnetic radiation, said beam of electromagnetic radiation being caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing

system element, interact with said sample system in a plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system, and enter said detector system;

f. by utilizing said mathematical model provided in step d. and said spectroscopic set of ellipsometric data obtained in step e., simultaneously evaluating sample system DELTA'S in correlation with in-plane orthogonal component retardation entered to said beam of electromagnetic radiation by each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, and parameters in said mathematical model parameterized equations for out-of-plane retardance entered by said input electromagnetic beam intercepting angle-of-incidence changing system element and said output electromagnetic beam intercepting angle-of-incidence changing system element to a beam of electromagnetic radiation caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system, interact with said sample system in said plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system element;

to the end that application of said parameterized equations for out-of-plane retardance entered by said input electromagnetic beam intercepting angle-of-incidence changing system element and said output electromagnetic beam intercepting angle-of-incidence changing system element to a beam of electromagnetic radiation caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system, interact with said sample system in said plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system element, for which values of

parameters therein are determined in step f., enables independent calculation of retardance entered to said out-of-plane orthogonal component of a beam of electromagnetic radiation by each of said input and output electromagnetic beam intercepting angle-of-incidence changing systems.

31. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system element as in Claim 30, in which the step f. simultaneous evaluation of parameters in said mathematical model parameterized equations for calculation of retardance entered to said out-of-plane orthogonal component of a beam of electromagnetic radiation by each of said input and output electromagnetic beam intercepting angle-of-incidence changing system element and said correlated sample system DELTA'S and retardance entered to said in-plane orthogonal component of a beam of electromagnetic radiation by each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, is achieved by a square error reducing mathematical curve fitting procedure.

32. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 30, which further comprises the steps of:

g. providing a parameterized equation for retardation entered by said sample system to the in-plane orthogonal component of a beam of electromagnetic radiation, and as necessary similar parameterized equations for retardation entered by each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements to the in-plane

orthogonal component of a beam of electromagnetic radiation; and

h. by utilizing said parameterized mathematical model provided in step d. and said spectroscopic set of ellipsometric data obtained in step e., simultaneously evaluating parameters in said mathematical model parameterized equations for independent calculation of retardance entered in-plane by said sample system and by said input electromagnetic beam intercepting angle-of-incidence changing system element and said output electromagnetic beam intercepting angle-of-incidence changing system element such that the correlation between sample system DELTA'S and the retardance entered by said in-plane orthogonal component of a beam of electromagnetic radiation by each of said input and output electromagnetic beam intercepting angle-of-incidence changing systems, at given wavelengths in said spectroscopic set of ellipsometric data, is broken;

to the end that application of said parameterized equations for each of said input electromagnetic beam intercepting angle-of-incidence changing system element, output electromagnetic beam intercepting angle-of-incidence changing system and sample system for which values of parameters therein have been determined in step h., enables independent calculation of retardance entered to both said out-of-plane and said in-plane orthogonal components of a beam of electromagnetic radiation by each of said input and output electromagnetic beam intercepting angle-of-incidence changing systems, and retardance entered by said sample system to said in-plane orthogonal component of said beam of electromagnetic radiation, at given wavelengths in said spectroscopic set of ellipsometric data.

33. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam

intercepting angle-of-incidence changing system elements, as in Claim 32, in which the step h. simultaneous evaluation of parameters in said mathematical model parameterized equations for said in-plane retardation entered by said parameterized sample system, and said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, is achieved by a square error reducing mathematical curve fitting procedure.

34. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements, as in Claim 30, which further comprises the steps of:

g. removing the sample system from said means for supporting a sample system positioned between said input and output electromagnetic beam intercepting angle-of-incidence changing systems, and positioning in its place an alternative sample system for which a parameterized equation for calculating in-plane retardance entered to a beam of electromagnetic radiation, can be provided;

h. providing a parameterized equation for retardation entered in-plane to an orthogonal component of a beam of electromagnetic radiation by said alternative sample system which is then positioned on said means for supporting a sample system positioned between said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, and as necessary similar parameterized equations for retardation entered by each of said input and output electromagnetic beam intercepting angle-of-incidence changing systems to the in-plane orthogonal component of a beam of electromagnetic radiation;

i. obtaining a spectroscopic set of ellipsometric data with said alternative sample system present on the means for supporting a sample system, utilizing a beam of electromagnetic radiation provided by said source of electromagnetic radiation, said beam of electromagnetic radiation being caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, interact with said alternative sample system in a plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence changing system element and enter said detector system;

j. by utilizing said parameterized mathematical model for said input electromagnetic beam intercepting angle-of-incidence changing system element, and said output electromagnetic beam intercepting angle-of-incidence changing system element, provided in step d. and said parameterized equation for retardation entered by said alternative sample system provided in step h., and said spectroscopic set of ellipsometric data obtained in step i., simultaneously evaluating parameters in said mathematical model parameterized equations for independent calculation of retardance entered to an in-plane orthogonal component of said beam of electromagnetic radiation by said alternative sample system and by said input electromagnetic beam intercepting angle-of-incidence changing system element and said output electromagnetic beam intercepting angle-of-incidence changing system element, such that correlation between DELTA'S entered by said alternative sample system and retardance entered by said in-plane orthogonal component of said beam of electromagnetic radiation, by each of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, at given wavelengths in said spectroscopic set of ellipsometric data, is broken, said simultaneous evaluation optionally

providing new values for parameters in parameterized equations for calculation of retardance entered in said out-of-plane components of said beam of electromagnetic radiation by each of said input electromagnetic beam intercepting angle-of-incidence changing system element and said output electromagnetic beam intercepting angle-of-incidence changing system element;

to the end that application of said parameterized equations for each of said input electromagnetic beam intercepting angle-of-incidence changing system element, output electromagnetic beam intercepting angle-of-incidence changing system and alternative sample system, for each of which values of parameters therein have been determined in step j., enables independent calculation of retardance entered to both said out-of-plane and said in-plane orthogonal components of a beam of electromagnetic radiation by each of said input electromagnetic beam intercepting angle-of-incidence changing system and said output electromagnetic beam intercepting angle-of-incidence changing system element, and retardance entered by said alternative sample system to said in-plane orthogonal component of a beam of electromagnetic radiation, at given wavelengths in said spectroscopic set of ellipsometric data.

35. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 34, in which the step j. simultaneous evaluation of parameters in said mathematical model parameterized equations for said in-plane retardation entered by said parameterized sample system, and at least said in-plane input electromagnetic beam intercepting angle-of-incidence changing system element and output electromagnetic beam intercepting angle-of-incidence

changing system element, is achieved by a square error reducing mathematical curve fitting procedure.

36. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 30, in which the step b. positioning of an ellipsometer system source of electromagnetic radiation and an ellipsometer system detector system includes positioning a polarizer between said source of electromagnetic radiation and said input electromagnetic beam intercepting angle-of-incidence changing system, and the positioning of an analyzer between said output electromagnetic beam intercepting angle-of-incidence changing system and said detector system, and in which the step e. obtaining of a spectroscopic set of ellipsometric data involves obtaining data at a plurality of settings of at least one component selected from the group consisting of:

said analyzer;and
said polarizer.

37. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements, as in Claim 34, in which the step b. positioning of an ellipsometer system source of electromagnetic radiation and an ellipsometer system detector system includes positioning a polarizer between said source of electromagnetic radiation and said input electromagnetic beam intercepting angle-of-incidence changing system, and the positioning of an analyzer between said output electromagnetic beam intercepting angle-of-incidence changing system and said detector system, and in which the step i.

obtaining of a spectroscopic set of ellipsometric data involves obtaining data at a plurality of settings of at least one component selected from the group consisting of:

said analyzer;and
said polarizer.

38. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 30, in which the step of providing separate parameterized mathematical model parameterized equations for enabling independent calculation of out-of-plane retardance entered by said input and said output electromagnetic beam intercepting angle-of-incidence changing system elements to said beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, involves parameterized equations having a form selected from the group consisting of:

$$ret(\lambda) = K1 + (K2/\lambda^2) + (K3/\lambda^4)$$
$$ret(\lambda) = (K1/\lambda)$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2))$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2) + (K3/\lambda^4)).$$

39. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 32, in which the step of providing separate parameterized mathematical model parameterized equations for retardance entered to the out-of-plane and in-plane orthogonal components of a beam of electromagnetic radiation caused to pass through said input

and output electromagnetic beam intercepting angle-of-incidence changing system elements, thereby enabling independent calculation of out-of-plane and in-plane retardance entered by said input and said output electromagnetic beam intercepting angle-of-incidence changing system elements to out-of-plane and in-plane orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, and the step of providing a parameterized equation for in-plane retardance entered by interaction of said bean of electromagnetic radiation with said sample system involve, for each input and output electromagnetic beam intercepting angle-of-incidence changing systems orthogonal retardation component and for said sample system retardation, parameterized equations having a form selected from the group consisting of:

$$ret(\lambda) = K1 + (K2/\lambda^2) + (K3/\lambda^4)$$
$$ret(\lambda) = (K1/\lambda)$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2))$$
$$ret(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2) + (K3/\lambda^2)).$$

40. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 34, in which the step of providing separate mathematical model parameterized equations for retardance entered to the out-of-plane and in-plane orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements, thereby enabling independent calculation of out-of-plane and in-plane retardance entered by said input and said output electromagnetic beam intercepting

angle-of-incidence changing system elements to out-of-plane and in-plane orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing systems, and the step of providing a parameterized equation for in-plane retardance entered by interaction of said bean of electromagnetic radiation with said alternative sample system involve, for each input and output electromagnetic beam intercepting angle-of-incidence changing system elements orthogonal retardation component and for said alternative sample system retardation, parameterized equations having a form selected from the group consisting of:

$$\mathrm{ret}(\lambda) = K1 + (K2/\lambda^2) + (K3/\lambda^4)$$
$$\mathrm{ret}(\lambda) = (K1/\lambda)$$
$$\mathrm{ret}(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2))$$
$$\mathrm{ret}(\lambda) = (K1/\lambda)*(1 + (K2/\lambda^2) + (K3/\lambda^4)).$$

41. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 30, in which the step a. providing of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements involves providing input and output electromagnetic beam intercepting angle-of-incidence changing system elements which are mounted on an X, Y, Z orientation control system.

42. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 34, in which the step a. providing of spatially separated

input and output electromagnetic beam intercepting angle-of-incidence changing system elements involves providing input and output electromagnetic beam intercepting angle-of-incidence changing system elements which are mounted on an X, Y, Z orientation control system.

43. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claims 20 or 30, which further involves, in a functional order:

fixing evaluated parameter values in mathematical model parameterized equations, for each of said input electromagnetic beam intercepting angle-of-incidence changing system element and output electromagnetic beam intercepting angle-of-incidence changing system element, such that said parameterized equations allow independent determination of retardation entered between orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system elements; and

causing an unknown sample system to be present on said means for supporting a sample system;

obtaining a spectroscopic set of ellipsometric data with said unknown sample system present on the means for supporting a sample system, utilizing a beam of electromagnetic radiation provided by said source of electromagnetic radiation, said beam of electromagnetic radiation being caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, interact with said alternative sample system in a plane of incidence thereto, and exit through said output electromagnetic beam intercepting angle-of-incidence

changing system element and enter said detector system; and

by utilizing said mathematical model for said input electromagnetic beam intercepting angle-of-incidence changing system and said output electromagnetic beam intercepting angle-of-incidence changing system element in which parameter values in mathematical model parameterized equations, for each of said input electromagnetic beam intercepting angle-of-incidence changing system element and output electromagnetic beam intercepting angle-of-incidence changing system have been fixed, simultaneously evaluating PSI'S and uncorrelated DELTA'S parameters for said unknown sample system.

44. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claims 43, in which said simultaneous evaluation of PSI'S and DELTA'S for said unknown sample are achieved by a square error reducing mathematical curve fitting procedure.

45. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claims 20 or 30, in which the step of providing spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements, at least one of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements demonstrating birefringence when a beam of electromagnetic radiation is caused to pass therethrough, involves one electromagnetic beam intercepting angle-of-incidence changing system element which is not birefringent.

46. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claim 45, in which said at least one electromagnetic beam intercepting angle-of-incidence changing system element which is not birefringent is essentially a surrounding ambient.

47. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system element as in Claims 24 or 25 in which the step b. positioning of an ellipsometer system source of electromagnetic radiation and an ellipsometer system detector system includes positioning additional elements between said source of electromagnetic radiation and said input electromagnetic beam intercepting angle-of-incidence changing system element, and/or between said output electromagnetic beam intercepting angle-of-incidence changing system element and said detector system, and in which the step e. obtaining of a spectroscopic set of ellipsometric data involves obtaining data at a plurality of settings of at least one of said additional components.

48. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system element as in Claims 20 or 30 which further involves, in a functional order:

fixing evaluated parameter values in mathematical model parameterized equations, for each of said input electromagnetic beam intercepting angle-of-incidence changing system element and output electromagnetic beam intercepting angle-of-incidence

changing system element, such that said parameterized equations allow independent determination of retardation entered between orthogonal components of a beam of electromagnetic radiation caused to pass through said input and output electromagnetic beam intercepting angle-of-incidence changing system element; and

causing an unknown sample system to be present on said means for supporting a sample system;

obtaining a spectroscopic set of ellipsometric data with said unknown sample system present on the means for supporting a sample system, utilizing a beam of electromagnetic radiation provided by said source of electromagnetic radiation, said beam of electromagnetic radiation being caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, interact with said alternative sample system in a plane of incidence thereto, and exit through said output electromagnetic radiation being caused to pass through said input electromagnetic beam and enter said detector system; and

by utilizing said mathematical model for said input electromagnetic beam intercepting angle-of-incidence changing system and said output electromagnetic beam intercepting angle-of-incidence changing system element in which parameter values in mathematical model parameterized equations, for each of said input electromagnetic beam intercepting angle-of-incidence changing system element and output electromagnetic beam intercepting angle-of-incidence changing system have been fixed, simultaneously evaluating ALPHA'S and BETA'S for said unknown sample system;

applying transfer functions to said simultaneously evaluated ALPHA'S and BETA'S for said unknown sample system to the end that

a data set of effective PSI's and DELTA's for a combination of said electromagnetic beam intercepting angle-of-incidence changing system element and said sample system is provided;

providing a mathematical model for said combination of said electromagnetic beam intercepting angle-of-incidence changing system and said sample system which separately accounts for the retardation effects of the presence of said electromagnetic beam intercepting angle-of-incidence changing system element and said sample system by parameterized equations; and

by utilizing said mathematical model for said combination of said electromagnetic beam intercepting angle-of-incidence changing system element and said sample system which separately accounts for the effects of the presence of at least said electromagnetic beam intercepting angle-of-incidence changing system by parameterized equations; and said data set of effective PSI's and DELTA's for a combination of said electromagnetic beam intercepting angle-of-incidence changing system and said sample system, simultaneously evaluating actual PSI's and DELTA's for said unknown sample system per se.

49. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system element as in Claim 48 in which the step of providing a mathematical model for said combination of said electromagnetic beam intercepting angle-of-incidence changing system elements and said sample system which separately accounts for the retardation effects of the presence of said input and output electromagnetic beam intercepting angle-of-incidence changing system elements and said sample system by parameterized equations which further includes

providing for the effects of handedness.

50. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements as in Claims 48 or 49, in which said evaluation of actual PSI's and DELTA's is achieved by a square error reducing mathematical curve fitting procedure.

51. A method of accurately evaluating parameters in parameterized equations in a mathematical model of a system of spatially separated input and output electromagnetic beam intercepting angle-of-incidence changing system elements, as in Claims 20, 26 and 30; wherein the step e. obtaining of a spectroscopic set of ellipsometric data with said sample system present on the means for supporting a sample system further involves obtaining spectroscopic data for the case wherein said beam of electromagnetic radiation is not caused to pass through said input electromagnetic beam intercepting angle-of-incidence changing system element, but rather interacts with said sample system in a plane of incidence thereto, and enters said detector system without passing through the angle-of-incidence changing system elements before or after the sample system, such that said spectroscopic data set is multi-dimensional with reliance on at least both wavelength and more than one angle-of-incidence.